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REPORT

What did Simon say? Revisiting the bilingual advantage

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Abstract

Bilingual children often outperform monolingual children in tasks of cognitive control. This advantage may be a consequence of the fact that bilinguals have more practice controlling attention due to an ongoing need to manage two languages. However, existing evidence is limited because possible differences in ethnicity and socioeconomic status have not been properly controlled. To address this issue, we administered the Simon task to bilingual and monolingual children of identical ethnic and socioeconomic backgrounds. Bilingual and monolingual children performed identically, whereas children from higher SES families were advantaged relative to children from lower SES families. Controlling differences in SES and ethnicity may attenuate the bilingual advantage in cognitive control.

Introduction

Cognitive control, or the ability to act according to goals and resist interference, is a central part of higher-order thought (Gray, Chabris & Braver, 2003) that shows age-related improvements well into adolescence (Luna, Garver, Urban, Lazar & Sweeney, 2004). There is considerable inter-individual variation in the development of cognitive control, raising interesting questions concerning genetic (Diamond, Briand, Fossella & Gehlbach, 2004; Reuda, Rothbart, McCandliss, Saccomanno & Posner, 2005) and experiential (Farah & Noble, 2005; Mezzacappa, 2004; Noble, Norman & Farah, 2005; Reuda *et al*., 2005) contributions to the development of higher-order cognition. There is, for example, growing evidence that bilingual children outperform monolingual children in a variety of selective attention and cognitive flexibility tasks (Bialystok, 1988, 1999; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Bialystok & Shapero, 2005). For example, in the Simon task, participants respond to the colour of a stimulus in the face of spatial distraction. Coloured squares (e.g. red and green) are presented on either side of fixation and are associated with keyboard responses aligned with the presentation locations. Red squares, for example, may be associated with a key press on the right, and green squares with a key press on the left. On congruent trials, stimuli appear on the same side as their associated key press (e.g. red squares on the right); on incongruent trials, they appear on the opposite side (e.g. red squares on the left). Although attending to the colour of a stimulus while ignoring its spatial location is difficult for children – responses to incongruent trials are typically slower and less accurate than responses to congruent trials – bilinguals are faster (Bialystok, 2006) and more accurate (Baker, Kovelman, Bialystok & Petitto, 2003) than monolinguals on critical incongruent trials. This effect, often termed the 'bilingual advantage', has been observed across the lifespan in a variety of different tasks (Bialystok, 1988, 1999; Bialystok & Craik, in press; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Bialystok & Shapero, 2005; Bialystok, Craik, Klein & Viswanathan, 2004).

The prevailing interpretation of the bilingual advantage is that bilingual children have added practice exercising selective attention and cognitive flexibility due to the ongoing demands of coordinating two languages. On this account, bilingual children's two languages are active during normal language use (Brysbaert, 1998; Francis, 1999; Smith, 1997), and so in order to speak fluently and avoid unwanted intrusions, bilingual children need to inhibit their non-target language, a process that may rely on domain-general suppression mechanisms (Bialystok, 2001; Green, 1998). Because this need is ongoing, bilingual children acquire considerable practice with selection and inhibition, and over time become more efficient at exercising control.

However, it is possible that differences in monolingual and bilingual children's attention control derive in part from differences in ethnicity and socioeconomic status

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(SES), variables that have been linked both theoretically (Rogoff, Mistry, Göncü & Mosier, 1993; Ruff & Rothbart, 1996) and empirically (e.g. Farah & Noble, 2005; Mezzacappa, 2004; Noble *et al*., 2005; NICHD, 2003) to the development of attention. High-SES children show faster and less error-prone performance on measures of alerting and executive attention compared to low-SES children, and Caucasian children show more distraction on measures of executive attention than African-American and Hispanic children (Mezzacappa, 2004). And middle-SES kindergartners outperform low-SES kindergartners on measures of language and executive functioning, but show comparable performance on measures of visual cognition, visuospatial processing, and memory (Farah & Noble, 2005; Noble *et al*., 2005). Thus, differences in SES appear to selectively impact neurocognitive systems underlying higher-order cognition.

Although the precise mechanisms underlying these associations remain unclear, current findings suggest the importance of several social, emotional and neuropsychological factors. Parents, for example, play an important role in directing and regulating their children's attention to objects and events (Parrinello & Ruff, 1988; Ruff & Rothbart, 1996; Saxon, Frick & Columbo, 1997) through episodes of joint attention (Bakeman & Adamson, 1984; Landry & Chapieski, 1989) and the provision of emotional warmth and sensitivity (Linver, Brooks-Gunn & Kohen, 2002; Kochanska, Murray & Harlan, 2000). Moreover, both the quality and frequency of these aspects of parent–child interaction vary with differences in family income and parental education (Conger, Ge, Elder, Lorenz & Simons, 1994; Conger, Patterson & Ge, 1995; Linver *et al*., 2002), and have profound and specific effects on the development of prefrontal cortex functioning (Farah & Noble, 2005; Noble *et al*., 2005).

Although bilingualism researchers have long acknowledged the importance of social variables (Cummins, 1976; Reynolds, 1991), studies that compare bilingual and monolingual children on measures of cognitive control often confound ethnicity and language status and never measure SES. For example, studies that report an advantage for bilingual children on the Dimensional Change Card Sort (DCCS; Zelazo, Frye & Rapus, 1996) compared Canadian English monolinguals and Canadian Chinese-English bilinguals and did not measure SES (Bialystok, 1999; Bialystok & Martin, 2004). Other studies compared Canadian English monolinguals and Canadian immigrant bilinguals drawn from up to 15 different language and ethnic groups and did not measure SES (Bialystok, 1986, Experiment 1; Bialystok & Senman, 2004, Experiment 2; Bialystok & Shapero, 2005). And although some studies find the bilingual advantage after controlling for differences in ethnicity (e.g. studies of grammaticality judgements; Bialystok, 1988; Bialystok, 1986, Experiment 2), none measured SES.

Comparisons of bilingual and monolingual children drawn from immigrant and non-immigrant Canadian populations respectively (e.g. Bialystok, 1999; Bialystok, 1986, Experiment 1; Bialystok & Martin, 2004; Bialystok & Senman, 2004, Experiment 2; Bialystok & Shapero, 2005), are particularly difficult to interpret because these populations differ in SES in complex but important ways. On the one hand, average family income is marginally lower for immigrant Canadian families ($64,402 CAD) than for non-immigrant Canadian families ($66,807 CAD; Canada Census 2001). On the other hand, immigrant Canadians are more educated than non-immigrant Canadians, due to an immigration policy that selects candidates on the basis of their academic achievement, language, and occupational skills. For example, according to the 2003 Report of the Pan-Canadian Education Indicators Programme (PCEIP; Statistics Canada, 2003a), 41% of immigrants arriving in Canada in the 1990s had completed university prior to immigrating, with 39% completing high school or less. By contrast, only 23% of working age Canadians (25 to 64 years) had completed university and 45% had completed high school or less. Similarly, according to the 2001 Longitudinal Survey of Immigrants to Canada (LSIC; Statistics Canada, 2003b), over half (55%) of immigrants who arrived in 2001 reported having a university education, with this proportion being even higher among newcomers aged 25 to 44 years (69%). This was more than three times the 22% of the Canadian-born population in the same age group in 2001.

The purpose of the present study then was to undertake a more stringent test of the hypothesis that bilingual children's advantage in cognitive control stems from their knowledge of two languages by comparing two samples of children that differed in language status but not ethnicity or SES. Monolingual and bilingual children aged 6 to 7 years were recruited from a city in Ontario, Canada which is predominantly English speaking but has a small French-speaking population that has lived in the region for several generations. These individuals speak French and English fluently, raise their children in French, and their children receive elementary and high school education through a separate French language school board but are otherwise indistinguishable from members of the anglophone community. To ensure the groups differed only in language status, we measured children's SES, vocabulary, and non-verbal intelligence. We then compared the groups in terms of their performance on a version of the Simon task that was identical to that used in previous studies of bilingual and monolingual children (Martin & Bialystok, 2003) and adults (Bialystok *et al.*, 2004, Experiment 1).

Our predictions were straightforward. If growing up knowing two languages affords children an advantage in tasks of cognitive control, then bilingual children should outperform monolingual children in the Simon task. Specifically, language status and trial type should interact, with bilingual and monolingual children performing similarly on easy trials (e.g. congruent trials of the Simon task) but bilingual children outperforming monolingual children on difficult trials (e.g. incongruent trials of the Simon task). However, if bilingual children outperform monolingual children because of differences in ethnicity and SES, then eliminating these differences should attenuate group differences. Specifically then, there should be a main effect of trial type but no interaction with language status. Finally, if SES is a critical determinant of variation in cognitive control, then an examination of monolingual and bilingual children together should reveal a significant association between SES and task performance.

Method

Participants

Participants included 34 children (16 male, 18 female) aged 6 to 7 years ($M = 6.88$ yrs). Seventeen (eight male, nine female) were monolingual (spoke only English); 17 (eight male, nine female) were bilingual (spoke English and French). All children were from families who had agreed to participate voluntarily in child development research. Bilingual children were recruited through local French language schools. Monolingual children were recruited through local birth announcements. Monolingual children were considered eligible participants if their parents indicated at the time of recruitment that their child spoke only English.

Tasks and procedures

Participants were tested individually in a small quiet room either adjacent to their school classroom (bilingual children) or in a university laboratory (monolingual children). Tasks included the Simon task, vocabulary measures, and a test of non-verbal intelligence (MAT; Naglieri, 1985). Parents completed background information questionnaires either in the laboratory as their children were being tested (monolingual children) or at home, returning them to the experimenter through their child (bilingual children).

Peabody Picture Vocabulary Test-Revised (PPVT-R)

All children completed the PPVT (Dunn, Dunn & Dunn, 1997), a standardized measure of English receptive vocabulary. Children are shown four pictures, and asked to point to the picture that corresponds with the word spoken by the experimenter. The procedure begins by defining a basal level of performance and continues in sets of 12 increasingly difficult words until the child makes eight or more errors in a single set. Standardized tables are used to convert raw scores to standard scores.

Échelle de Vocabulaire en Images Peabody (EVIP)

All bilingual children completed the EVIP (Dunn, Thériault-Whalen & Dunn, 1993), which is the French equivalent of the PPVT-R.

Matrix Analogies Test (MAT)

All children completed the MAT (Naglieri, 1985), a standardized test of non-verbal intelligence containing four sub-tests: (1) pattern completion; (2) analogical reasoning; (3) serial reasoning; and (4) spatial visualization. Sub-tests consist of individual trials featuring images or sets of images with one piece/image missing. Participants choose the missing piece/image from the various options at the bottom of the page. Testing within a sub-test continues until a participant makes four consecutive errors, and then switches to the next sub-test. Raw scores, calculated as the sum of correct responses in the four sub-tests, are standardized using an age norms table.

Questionnaires

All parents were asked to complete a Parent Information Questionnaire in which they indicated their own and their spouse's/partner's country of origin, occupation, and highest level of education, as well as their total family income. Each parent received a score between 1 and 5 depending on their level of academic achievement (e.g. high school or less = 1; high school plus six or more years of university = 5). Also, families received a score from 1 to 4 depending on their total income (e.g. < \$20,000 = 1; \$20,000–\$40,000 = 2; etc.). Parent education scores were averaged and combined with income scores to create a composite SES score that could range from 2 to 9. Parents of bilingual children completed a Daily Language Use Questionnaire in which they indicated whether their child spoke French, English, French and English, or a third language when in the company of their: (1) father; (2) mother; (3) sibling(s); (4) grandparents; (5) friends; and during (6) extra-curricular activities. Responses were used to estimate their child's daily use of English.

Simon task

All children completed a computer-based version of the Simon task administered on a Toshiba Satellite 5100

using E-Prime Software. Children sat facing the computer and the experimenter sat beside them. On each trial, a coloured square was presented in either the bottom left or the bottom right corner of the monitor. Participants were instructed that when the square was red, they were to press as quickly and accurately as possible a key marked with a red sticker located on the left side of the computer keyboard ('z' key); when the square was green, they were to press a key marked with a green sticker located on the right side of the computer keyboard (the right 'Shift' key). On congruent trials, the colour of the stimulus matched the side of the response (e.g. a red square was presented on the left); on incongruent trials, they mismatched (e.g. a red square was presented on the right). Following Bialystok *et al.* (2004, Experiment 1), there were a total of 28 trials, half congruent and half incongruent, with the order of trials randomized for each participant, and performance feedback provided after every trial. One demonstration trial and two practice trials ensured that children understood the instructions. In past research, this exact task administered to 40 participants yielded a strong Language Status × Trial-Type interaction ($f = 0.6$; based on Bialystok *et al.*, 2004, Experiment 1). Thus, the current design had adequate power to detect a similar interaction ($\beta \sim .96$, assuming $\alpha = .01$).

Results

Results are summarized in Tables 1 and 2.

Background variables

Monolingual and bilingual samples were not different in age (for monolinguals, $M = 82.5$ months, SD = 5.4; for bilinguals, $M = 82.5$ months, SD = 7.7), male/female ratio (both groups consisted of eight males, nine females), or general intelligence (mean standard MAT scores for monolingual and bilingual children were 111.0 (SD = 7.1) and 111.2 (SD = 9.8), respectively, $t(32) = 0.08$, *ns*; see Table 1).

Table 1 *Measures (and standard deviations) by language group*

Measure	Monolinguals (SD)	Bilinguals (SD)
N	17	17
Age in months	82.5 (5.4)	82.5 (7.7)
MAT	111.0 (7.1)	111.2 (9.8)
PPVT-R	110.1 (18.8)	100.3 (15.2)
EVIP	N/A	97.8 (16.4)
SES	6.6 (1.3)	7.1 (1.0)
Language use	100%	58.3% (17.0)

Note: MAT = Matrix Analogies Test; PPVT-R = Peabody Picture Vocabulary Test-Revised; EVIP = Échelle de Vocabulaire en Images Peabody; SES = Composite measure of socioeconomic status based on parent education and total family income; Language use = Percent of daily language use in English.

Table 2 *Mean response times and errors on the Simon task*

	Monolinguals (n = 17)		Bilinguals (n = 17)	
Trial type	RT (SD)	Errors (SD)	RT (SD)	Errors (SD)
Congruent	901.4 (322.2)	0.7 (0.9)	947.2 (426.5)	0.3 (0.4)
Incongruent	980.8 (243.5)	1.1 (1.3)	1099.0 (496.6)	1.6 (1.3)

Vocabulary

Monolingual and bilingual children had equivalent English vocabularies (Table 1). Average standard PPVT scores for monolingual and bilingual children were 110.1 (SD = 18.8) and 100.3 (SD = 15.2) respectively, $t(32) = 1.65$, *ns*. Bilingual children's French and English vocabularies were also equivalent. Their average standard EVIP scores were 97.8 (SD = 16.4), which were not different from their PPVT scores, $t(16) = 0.65$, *ns*. Bilingual children's EVIP scores were marginally lower than monolingual children's PPVT scores, $t(32) = 2.03$, $p = .051$.

Language use

Results of the Daily Language Use questionnaire indicated that bilingual children used English in approximately half of their daily social interactions ($M = 58.3\%$, SD = 17; see Table 1). Thus, bilingual children were not only proficient in French and English but they regularly used both languages every day in their interactions with parents, teachers, and peers. This is an important criterion for classifying an individual as truly bilingual (see Bialystok *et al.*, 2004).

SES and ethnicity

Monolingual and bilingual children had very similar socioeconomic backgrounds (Table 1). The comparison was based on data from 17 monolingual and 16 bilingual families, as parents of one bilingual child withheld information about their family's total income. The range of composite SES scores for monolingual and bilingual children was 3.0–8.5 and 5.0–8.5, respectively, and mean composite SES scores for monolingual and bilingual children were 6.6 (SD = 1.3) and 7.1 (SD = 1.0) respectively, $t(31) = 1.4$, *ns*, indicating that both groups generally had well-educated parents with middle-class incomes. Also, bilingual and monolingual children were all Canadian-born, and their parents were predominantly Canadian-born

Caucasians. Parents of bilingual children were all Canadian-born except for one mother; parents of monolingual children were all Canadian-born except for one mother and one father.

Simon task

Mean response times (RTs) for correct responses and accuracy scores for congruent and incongruent trials of the Simon task as a function of language group are shown in Table 2. Response times for correct responses were relatively stable for all participants. Therefore, no data reduction procedures were used. The RTs and error rates were examined with a two-way analysis of variance (ANOVA) for language group and trial type. Responses on incongruent trials were slower, $F(1, 32) = 8.65$, $p < .01$, $f = 0.35$ and less accurate, $F(1, 32) = 13.7$, $p < .01$, $f = 0.42$, than responses on congruent trials. There was, however, no effect of language group and no language group by trial type interaction.

SES and Simon task performance

To examine possible associations between SES and Simon task performance, bilingual and monolingual children's data were pooled, and then SES was correlated with measures of Simon cost, where cost was measured as the difference in performance on incongruent versus congruent trials separately for latency and errors. SES was negatively correlated with cost as measured by errors ($r = -.35$, $p < .05$; $\rho = 0.35$), indicating that children from higher SES families showed a smaller cost of conflict in the Simon task in terms of errors. Correlations remained unchanged after children's non-verbal intelligence (i.e. standardized MAT score) was partialled out, suggesting that the association between SES and Simon cost was not simply due to differences in children's intelligence (Linver *et al*., 2002).

Discussion

Bilingual and monolingual children showed similar performance in the Simon task. Both groups were slower and more error-prone on incongruent compared with congruent trials, but did not differ from each other. Bilingual children failed to show an advantage despite their command of two languages. Their French and English vocabularies were both at age-appropriate levels, and according to their parents, they used French and English every day when interacting with family, friends, and peers.

It should be noted that prior evidence of a bilingual advantage in the Simon task is not without controversy. Somewhat inconsistent with the notion that bilingualism selectively benefits cognitive control, several studies report that bilingual children (Baker *et al*., 2003; Bialystok, 2006; Martin & Bialystok, 2003) and adults (Bialystok *et al*., 2004) are faster than monolinguals on both congruent and incongruent trials of the task. Importantly though, the magnitude of the Simon effect, or the difference in response time between incongruent and congruent trials, is generally smaller for bilingual children (Bialystok, 2006) and adults (Bialystok *et al.*, 2004) than monolingual children and adults. As such, the present results are at odds with prior evidence of a bilingual advantage in the Simon task (Baker *et al*., 2003; Bialystok, 2006; Bialystok *et al.*, 2004) and other tasks of cognitive control (Bialystok, 1988, 1999, 2001; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Bialystok & Shapero, 2005).

One possible reason for this discrepancy is that bilingual and monolingual children in the present study had comparable ethnic and socioeconomic backgrounds. Parental provision of emotional support (e.g. emotion regulation, warmth, and sensitivity) and cognitive stimulation (e.g. joint attention, direct teaching, bedtime reading, explaining events) contributes to the development of attention (Bakeman & Adamson, 1984; Landry & Chapieski, 1989; Linver *et al*., 2002; Kochanska *et al*., 2000) and its neural underpinnings (Farah & Noble, 2005; Noble *et al*., 2005), and is constrained by parents' level of education and access to financial resources (Conger *et al.*, 1994, 1995; Linver *et al*., 2002; NICHD, 2003). Consistent with this evidence, children from higher SES families were less vulnerable to the effects of conflict in the Simon task than were children from lower SES families even after controlling for differences in children's non-verbal IQ.

Although SES exerts a strong influence on the development of attention, perhaps more so than bilingualism (Mezzacappa, 2004), it has never been measured in studies of bilingualism and the development of attention (Bialystok, 1988, 1999, 2001; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Bialystok & Shapero, 2005; Martin & Bialystok, 2003). Indeed, a large body of evidence in support of the bilingual advantage is based on a comparison of bilingual and monolingual children drawn from Canadian immigrant and non-immigrant families, respectively (e.g. Bialystok, 1986, Experiment 1; Bialystok & Senman, 2004, Experiment 2; Bialystok & Shapero, 2005), despite the fact that the SES of these populations differs in complex but important ways (PCEIP Report, 2003). The present study is therefore important as it is the first to compare attention control in ethnically and socioeconomically identical bilingual and monolingual children. The results suggest that controlling for differences in ethnicity and SES can attenuate the bilingual advantage.

The present results are suggestive and clearly need to be balanced against a sizable body of literature suggesting that bilingualism has positive consequences for the development of attention. The sample size, while statistically adequate, is small, and comprised a limited range of ethnicities. However, at a minimum, they should serve as a reminder that the mechanisms by which the bilingual advantage is realized remain poorly understood. According to the prevailing interpretation, both bilingual children's languages are active in the course of daily language use and as a consequence, the non-target language interferes with production and comprehension in the target language. Attenuating this interference requires continuous inhibition of the non-target language (Green, 1998), which over time leads to more efficient inhibitory control through massive amounts of practice (Bialystok, 2001). Although there is abundant evidence that bilingual individuals' two languages are active in the course of everyday language use (Brysbaert, 1998; Francis, 1999; Smith, 1997), it is not clear that target language production demands the suppression of the non-target language. For example, bilinguals show faster picture naming in the presence of translation equivalents than semantically unrelated words (Costa, Miozzo & Caramazza, 1999) and fewer tip of the tongue phenomena and faster picture naming for translatable words (i.e. words with translation equivalents) than non-translatable words (Gollan & Acenas, 2004; Gollan, Montoya, Fennema-Notestine & Morris, 2005). On these data, non-target languages appear to facilitate rather than interfere with the use of a target language. Nor is it clear that accessing words in a target language causes translation equivalents to be inhibited. Retrieving words from a target language actually leads to faster rather than slower retrieval of translation equivalents (Gollan & Acenas, 2004; Gollan & Silverberg, 2001).

Switching between languages may provide a basis for practicing control. Bilingual children are slower and more error prone in picture-naming tasks under mixed language conditions that demand frequent switches between languages than in blocked language conditions that do not require switching (Kohnert, Bates & Hernandez, 1999), although these condition effects are not observed in comprehension tasks (Kohnert & Bates, 2002). These data suggest that switching between languages is effortful and may be a basis for practice effects. However, if this is true, then the frequency in the use of rather than proficiency in two languages ought to be the focus of research into the cognitive effects of bilingualism. Finally, prevailing accounts assume that practice effects accrue gradually over development and lead to stable differences between monolinguals and bilinguals in tasks of attention control (Bialystok, 2001). However, in one recent study of the bilingual advantage in the Simon task, these differences disappeared after only several blocks of practice (Bialystok *et al.*, 2004, Experiment 3). Although the findings highlight the importance of practice, they also suggest that such effects are quite proximal.

In sum, a proper understanding of the mechanisms by which bilingualism bestows cognitive benefits on the developing mind awaits a more detailed investigation of how bilingual children's target and non-target languages interact in the course of language processing (Kohnert & Bates, 2002; Kohnert *et al.*, 1999), how practice influences the development of attention control (Reuda *et al.*, 2005), and how differences in the socioeconomic, cultural and family background of monolingual and bilingual individuals impact their respective cognitive-developmental trajectories.

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